

## Professor Dr.-Ing. JÖRG E. DREWES

Colorado School of Mines, Environmental Science and Engineering Division, Golden, CO 80401-1887  
Phone: 303-273-3401 Fax: 303-273-3413 E-mail: jdrewes@mines.edu

### EDUCATION

Doctorate in Environmental Engineering (Ph.D.), Technical University of Berlin, Germany 1997

Dipl. Ing. Environmental Engineering (M.S.), Technical University of Berlin, Germany 1992

### EXPERIENCE

7/2007-present: **Visiting Associate Professor**, UNSW Water Research Centre, The University of New South Wales, Sydney, Australia.

4/2006-present: **Associate Professor**, Environmental Science and Engineering Division, Colorado School of Mines, Golden CO. **Director**, Advanced Water Technology Center (AQWATEC). Research and teaching in water supply engineering with an emphasis on advanced water treatment and fate of organic compounds in engineered and natural systems.

8/2001-4/2006: **Assistant Professor**, Environmental Science and Engineering Division, Colorado School of Mines, Golden CO.

9/1999-7/2001: **Associate Director**, National Center for Sustainable Water Supply (NCSWS), Arizona State University, Tempe, AZ. Coordination of multi-agency and multi-university research and research on character and fate of organics in natural and engineered systems leading to indirect potable reuse.

8/1997-8/1999: **Visiting Professor**, Arizona State University, Tempe, AZ. Research on advanced characterization techniques for organic carbon in groundwater recharge systems.

7/1992-7/1997: **Research Associate**, Technical University of Berlin, Germany, Research on advanced wastewater treatment using powdered activated carbon and ozonation prior to groundwater recharge. Teaching design of water treatment processes, water chemistry, and environmental analytical chemistry.

### RESEARCH INTEREST

Water and wastewater treatment engineering; desalination; treatment of co-produced water; potable and non-potable water reuse (soil-aquifer treatment, advanced oxidation and microfiltration/reverse osmosis); natural treatment systems (riverbank filtration, aquifer recharge and recovery); process performance assessments in indirect potable reuse; state-of-the-art characterization of natural and effluent organic matter; fate and transport of emerging contaminants (endocrine disrupting compounds, pharmaceutical residues, household chemicals) in natural and engineered systems.

### AWARDS and HONORS

Panel Member, National Research Council (NRC) on Water Reuse 2008-2010; American Water Works Association Rocky Mountain Section Outstanding Research Award, 2007; Dr. Nevis Cook Graduate Teaching Award, Colorado School of Mines, 2003. Quentin Mees Research Award for outstanding water-related environmental research in the State of Arizona, 1999. Research Scholarship administered by the Deutsche Forschungsgemeinschaft (DFG), 1997 – 1999. Willy-Hager Award for outstanding research in the field of water and wastewater treatment, Germany, 1997.

### PROFESSIONAL AFFILIATIONS AND SERVICE

Member, Editorial Board *Journal of Environmental Science and Health*. Member, American Water Works Association (AWWA); Water Environment Federation (WEF); International Water Association (IWA); American Membrane Technology Association (AMTA); North American Membrane Society (NAMS); Association of Environmental Engineering & Science Professors (AEESP), Member, Project Advisory Committee, Water Research Foundation, Environmental Protection Agency, Water Environment Research Foundation (WERF), and WaterReuse Foundation (WRF). Member, WEF Water Reuse Committee. Member, Rocky Mountain Section AWWA/WEA Water Reuse Committee. Member, Blue Ribbon Panel, City of Aurora, Colorado. Member, Reference Panel, Western Corridor Project, Queensland, Australia. Peer review for scientific journals (*Env. Sci. & Techn.*, *J. Env. Sci. and Health*, *Chemosphere*, *Water Research*, *J. Membrane Science*, *J. Env. Eng.*, et al.).

## **CURRENT AND COMPLETED RESEARCH PROJECTS** (exceeding \$9.8M, selected projects listed)

Co-PI – “Trace Organic Compounds Removal during Wastewater Treatment – Categorizing Wastewater Treatment Processes by their Efficacy in Reduction of a Suite of Indicator TOC”. 2009-2011. PI A. Salveson (Carollo), Co-PIs Drs. Snyder (SNWA), Dickenson (CSM), Rauch-Williams (Carollo). Water Environment Research Foundation (WERF) CEC4R08.

PI – “An Integrated Framework for Management and Treatment of Produced Water”. 2008-2010. Co-PIs Drs. Cath and Xu (CSM), J. Graydon (Kennedy/Jenks), and J. Veil and S. Synder (Argonne Ant. Lab.) U.S. Dept. of Energy.

Co-PI – “Maximizing Recovery of Recycled Water for Groundwater Recharge”. 2009-2010. PI. C. Yu (PSOMAS). Co-PI C. Bellona (CSM). WaterReuse Foundation WRF-08-010.

Co-PI – “Water Reuse 2030”. PI K. Linden (CU-Boulder), Co-PI S. Khan (UNSW, Australia). 2009-2010. WaterReuse Foundation WRF-06-017.

PI - “Predictive Models to Aid in the Design of Membrane Systems for Organic Micropollutants Removal”. 2008-2010. Co-PIs Dr. Chris Bellona and Mark Eberhart (CSM) and Dr. Shankar Chellam (University of Houston). WaterReuse Foundation WRF-06-009.

PI – “Field Evaluation of a Sequencing batch/Membrane Bioreactor Hybrid System for Decentralized Wastewater Treatment”. 2008-2011. Co-PI T. Cath (CSM). Aqua-Aerobics Systems, Inc.

Co-PI – “Comparison of Chemical Composition of Reclaimed and Conventional Waters”. 2007-2008. PI Dr. Shane Snyder (SNWA), Co-PIs Dr. Eric Dickenson (CSM) and Brett Vanderford (SNWA). WaterReuse Foundation WRF-06-006.

PI - “Development of Surrogates to Determine the Efficacy of Groundwater Recharge Systems for the Removal of Trace Organic Chemicals”. 2006-2009. Co-PIs Dr. Eric Dickenson (CSM) and Dr. Shane Snyder (SNWA). WaterReuse Foundation WRF-05-004.

Co-PI - “Critical Assessment of Implementing Desalination Technology”. 2007-2008. PI Dr. Pei Xu, Co-PIs Drs. Tzahi Cath and Andrea Schaefer (University of Edinburgh. Awwa Research Foundation.

PI – “Aquifer Recharge and Recovery City of Aurora”. CH2MHill/City of Aurora. 2/05-12/07.

Co-PI – “Evaluation of River Bank Filtration Systems to Optimize Removal of Bulk Organic Matter, Emerging Organic Micropollutants and Nutrients”. Awwa Research Foundation #3180. 1/06/12/07 (PI Ken Thompson, CH2MHill).

PI – “Multi-beneficial use of co-produced water through high-pressure membrane treatment and capacitive deionization technology.” 2004-2005. PI. U.S. Bureau of Reclamation/Mendell Energy, Inc.

Co-PI – “Comprehensive Utility Guide for Endocrine Disruptors and Pharmaceuticals in Drinking Water. Awwa Research Foundation #3033. 4-05-8/06 (PI Shane Snyder, SNWA).

Co-PI – “Desalination Product Water Recovery and Concentrate Volume Minimization”. Awwa Research Foundation #3030. 5/05-2/07. (PI Sandeep Sethi, Carollo Engineers).

PI – “Contributions of Household Chemicals to Municipal Wastewater Systems and the Environment”. Water Environment Research Foundation 03-CTS-21UR. 10/04-2/07.

PI - Development of Indicators and Surrogates for Chemical Contaminants in Water Reclamation Systems. WaterReuse Foundation 03-WRF-014. 1/05-12/06.

PI – “Comparison of NF and RO in terms of water quality and operational performance”. Awwa Research Foundation #3012. 1/04-4/06.

PI – “Rejection of organic micropollutants in high-pressure membranes applications leading to indirect potable reuse”. Water Reuse Foundation 02-WRF-001. 10/02-02/05.

Co-PI - “Removal of Endocrine Disruptors in Water Reclamation Processes”. Water Environment Research Foundation (WERF) and Water Reuse Task Force 01-HHE-20T. 6/02-11/05 (PI William Sonzogni, Wisconsin State Laboratory of Hygiene).

PI - “Comparison of Efficiencies of long-term Soil-Aquifer Treatment (SAT) and Best Available Technologies (reverse osmosis and nanofiltration membranes) for indirect potable reuse of domestic effluents”. National Water Research Institute (NWRI)/U.S. Bureau of Reclamation. 7/00-3/01.

Co-PI - „Investigation on soil-aquifer treatment for a sustainable water reuse“. Awwa Research Foundation/ U.S. Environmental Protection Agency. 9/97-10/03.

## **PUBLICATIONS** (Selection)

### **Papers in peer-reviewed journals**

Drewes, J. E. & Jekel, M. (1996), Simulation of Groundwater Recharge With Advanced Treated Wastewater, *Water Science & Technology* **33**, 10-11, 409-418.

Drewes, J. E. & Jekel, M. (1998), Behavior of DOC and AOX using advanced treated wastewater for groundwater recharge. *Water Research* **32**, 10, 3125-3133.

Drewes, J.E. & Fox, P. (1999), Fate of natural organic matter (NOM) during groundwater recharge using reclaimed water. *Water Science & Technology* **40**, 9, 241-248.

Drewes, J.E. & Fox, P. (2000), Effect of drinking water sources on reclaimed water quality in water reuse systems. *Water Environment Research* **72**, 3, 353-362.

- Drewes, J. E., Fox, P. & Nellor, M. (2000), Efficiency and Sustainability of Soil-Aquifer Treatment for Indirect Potable Reuse of Reclaimed Water. I. Chorus et al. (eds.), Water, Sanitation & Health. IWA Publishing, London, 227-232.
- Drewes, J. E. & Shore, L. S. (2001). Concerns about pharmaceuticals in water reuse, groundwater recharge, and animal waste. In: Ch. Daughton and T. L. Jones-Lepp (Eds.) American Chemical Society Symposium Series 791 "Pharmaceuticals and personal care products in the environment" No. 791, Washington, D.C., 206-228.
- Drewes, J.E., Fox, P. & Jekel, M. (2001), Occurrence of iodinated X-ray contrast media in domestic effluents and their fate during indirect potable reuse. *Journal of Environmental Science and Health, Part A* **36A**, 1633-1645.
- Drewes, J. E. & Shore, L. S. (2001), Concerns about pharmaceuticals in water reuse, groundwater recharge, and animal waste. In: Ch. Daughton and T. L. Jones-Lepp (Eds.) American Chemical Society Symposium Series 791 "Pharmaceuticals and personal care products in the environment" No. 791, Washington, D.C., 206-228.
- Drewes, J. E. & Fox, P. (2001), Source Water Impact Model (SWIM) – A new planning tool for indirect potable water reuse systems. *Water Science & Technology* **43** (10), 267-275.
- Drewes, J. E. & Croue, J.-P. (2002), New approaches for structural characterization of organic matter in drinking water and wastewater effluents. *Water Science & Technology – Water Supply* **2**, 2, 1-10.
- Drewes, J. E. & Summers, R. S. (2002). Removal of NOM during bank filtration: Current knowledge and research needs. In: C. Ray, Melin, G. and Linsky, R. (eds.), Riverbank filtration: Improving source water quality. Kluwer Academic Publishers, Dordrecht, The Netherlands. 303-310.
- Drewes, J. E., Heberer, T., Rauch, T. & Reddersen, K. (2003), Fate of pharmaceuticals during groundwater recharge. *J. Ground Water Monitoring and Remediation* **23**, 3, 64-72..
- Drewes, J. E., Reinhard, M., & Fox, P. (2003), Comparing microfiltration-reverse osmosis and soil-aquifer treatment for indirect potable reuse of water. *Water Research* **37**, 3612-3621.
- Kimura, K., Amy, G., Drewes, J. E., & Watanabe, Y. (2003). Adsorption of hydrophobic compounds onto NF/RO membranes – an artifact leading to overestimation of rejection. *J. Membrane Science* **221**, 89-101.
- Mansell, J. and Drewes, J. E. (2004). Fate of steroidal hormones during soil-aquifer treatment (SAT). *J. Ground Water Monitoring and Remediation*. **24**, 2, 94-101.
- Bellona, C., Drewes, J. E., Xu, P. & Amy, G. (2004). Factors affecting the rejection of organic solutes during NF/RO treatment – A literature review. *Water Research* **38**, 2795-2809.
- Mansell, J., Drewes, J. E., & Rauch, T., (2004). Removal mechanisms of endocrine disrupting compounds (steroids) during soil-aquifer treatment. *Water Science & Technology* **50**, 2, 229-237.
- Rauch, T. & Drewes, J.E. (2004). Assessing the removal potential of soil-aquifer treatment systems for bulk organic matter. *Water Science & Technology* **50**, 2, 245-253.
- Drewes, J. E. (2004). Fate and transport of organic constituents during ground water recharge using water of impaired quality. Risk Assessment of Waste Water Re-use on Groundwater Quality. J. Steenvoorden and T. Endreny (eds.). Wastewater Re-use and Groundwater Quality. International Association of Hydrological Sciences (IAHS) Publ. 285. 85-91. Oxfordshire, UK.
- Bellona, C. & Drewes, J. E. (2005). The role of physico-chemical properties of membranes and solutes for rejection of organic acids by nanofiltration membranes. *Journal of Membrane Science* **249**, 227-234.
- Xu, P., Drewes, J. E., Bellona, C., Amy, G., Kim, T., Adam, M. & Heberer, T. (2005). Rejection of emerging organic micropollutants in nanofiltration/reverse osmosis membrane applications. *Water Environment Research* **77**, 1, 40-48.
- Drewes, J. E., Hemming, J., Ladenburger, S., Schauer, J. & Sonzogni, W. (2005). An assessment of endocrine disrupting activity changes in water reclamation systems through the use of bioassays and chemical measurements. *Water Environment Research* **77**, 1, 12-23.
- Rauch, T. & Drewes, J. E. (2005). Quantifying biological organic carbon removal in groundwater recharge systems. *J. Environmental Engineering*, June, 909-923.
- Kim, T.-U., Amy, G. & Drewes, J. E. (2005). Rejection of trace organic compounds by high-pressure membranes. *Water Science & Technology* **51**, 6-7, 335-344.
- Drewes, J. E., Bellona, C., Oedekoven, M., Xu, P., Kim, T.-U., & Amy, G. (2005). Rejection of wastewater-derived micropollutants in high-pressure membrane applications leading to indirect potable reuse. *Environmental Progress* **24**, 4, 400-409.
- Rauch-Williams, T. & Drewes, J. E. (2006). Using soil biomass as an indicator for the biological removal of effluent-derived organic carbon during soil infiltration. *Water Research* **40**, 961-968.
- Drewes, J. E., Quanrud, D., Amy, G. & Westerhoff, P. (2006). Character of Organic Matter in Soil-Aquifer Treatment Systems. *J. Environmental Engineering* **11**, 1447-1458.
- Xu, P., Drewes, J. E., Kim, T., Bellona, C. & Amy, G. (2006). Effect of membrane fouling on transport of emerging organic contaminants in NF/RO membrane applications. *J. Membrane Science* **279**, 165-175.
- Xu, P. and Drewes, J. E. (2006). Viability of nanofiltration and ultra-low pressure reverse osmosis membranes for multi-beneficial use of methane produced water. *Sep. Pur. Techn.* **52**, 67-76.
- Amy, G. and Drewes, J. E. (2006). Soil-aquifer treatment (SAT) as a natural and sustainable wastewater reclamation/reuse technology: Fate of wastewater effluent organic matter (EfOM) and trace organic compounds. *Environmental Monitoring and Assessment* (in press).
- Drewes, J. E., Hoppe, C., & Jennings, T. (2006). Fate and transport of N-nitrosamines under conditions simulating full-scale groundwater recharge operations. *Water Environment Research* **78**, 13, 2466-2473.
- Sethi, S., Walker, S., Drewes, J. E., & Xu, P. (2006). Existing and emerging concentrate minimization and disposal practices for membrane systems. *Florida Water Resources Journal*, June, 38-48.
- Bellona, C. and Drewes, J. E. (2007). Viability of a low pressure nanofilter in treating recycled water for water reuse applications – A pilot-scale study. *Water Research* **41**, 3948-3958.

- Kim, T-U., Drewes, J.E., Summers, R.S., and Amy, G. (2007). Solute transport model for trace organic neutral and charged compounds through nanofiltration and reverse osmosis. *Water Research*, 41, 3977-3988.
- Sethi, S., Xu, P. and Drewes, J.E. (2007). When less is more. *Civil Engineering* 77, 9, 72-75.
- Xu, P., Drewes, J.E. and Heil, D. (2007). Beneficial use of co-produced water through membrane treatment: Technical-economic assessment. *Desalination* Vol 225/1-3 pp 139-155.
- Benko, K. and Drewes, J.E. (2008). Co-produced water in the Western United States: Geographical distribution, occurrence, and composition. *Environmental Engineering Science* 25, 2, 239-246.
- Trenholm, B., Vanderford, B.J., Drewes, J.E., & Snyder, S.A. (2008). Determination of household chemicals using gas chromatography and liquid chromatography with tandem mass spectroscopy. *J. Chromatography A*. 1190: 253-262.
- Bellona C., Oelker, G., Luna, J., Filteau, G., Amy, G. & Drewes, J.E. (2008). Comparing nanofiltration and reverse osmosis for drinking water augmentation. *J. American Water Works Association* 100:9, 102-116.
- Lowe, K., Van Cuyk, S., Siegrist, R. & Drewes, J. E. (2008). Field Evaluation of the Performance of Engineered Onsite Wastewater Treatment Units. *J. Hydrologic Engineering*, 13:8, 735-743.
- Drewes, J.E., Dickenson, E. R. V., Sedlak, D. L., and Snyder, S.A. (in review). Applying Surrogates and Indicators to Assess Removal Efficiency of Trace Organic Chemicals in Indirect Potable Reuse Systems: Oxidation Processes. *Environmental Science and Technology*.

### Peer-Reviewed Books and Book Contributions

- Drewes, J. E. & Jekel, M. (1996). Reuse of Advanced Treated Sewage Effluent for Groundwater Recharge. Nordic Hydrological Programme. Report No. 38. 161-167.
- Drewes, J. E., Bornhardt, C. & Jekel, M. (1996). Untersuchungen zur Nutzung von Klarwässern für eine Versickerung auf Rieselfeldböden. Schriftenreihe im Fachbereich Umwelt und Gesellschaft. Landschaftsentwicklung und Umweltforschung, Technische Universität Berlin, Berlin. Nr. 101. 93-100.
- Drewes, J. E. (1996). Wende zu einer nachhaltigen Wassernutzung. K.H. Hübler, U. Weiland (Eds.). Nachhaltige Entwicklung. Eine Herausforderung für die Forschung? Verlag für Wissenschaft und Forschung. Berlin. 153-166.
- Drewes, J. E. (1997). Behavior of organic compounds in domestic effluents used for groundwater recharge. Fortschritt-BerichteVDI-Verlag No 174, Umwelttechnik, Düsseldorf (in German).
- Drewes, J. E., Fox, P. & Ziegler, D. (1998). Impact of drinking water sources on refractory DOC in water reuse systems. Peters et al. (eds.), Artificial Recharge of Groundwater. Balkema, Rotterdam, 461-463.
- Drewes, J. E. (1998). Anforderungen an eine nachhaltige Wassernutzung in Berlin-Brandenburg. Forschungs- und Sitzungsberichte. Nachhaltige Raumentwicklung. Szenarien und Perspektiven für Berlin-Brandenburg. Band 205. Akademie fuer Raumforschung und Landesplanung. Hannover. 199-217.
- Drewes, J. E., Fox, P. & Nellor, M. (2000). Efficiency and Sustainability of Soil-Aquifer Treatment for Indirect Potable Reuse of Reclaimed Water. I. Chorus et al. (eds.), Water, Sanitation & Health. IWA Publishing, London, 227-232.
- Drewes, J. E. & Shore, L. S. (2001). Concerns about pharmaceuticals in water reuse, groundwater recharge, and animal waste. In: Ch. Daughton and T. L. Jones-Lepp (Eds.) American Chemical Society Symposium Series 791 "Pharmaceuticals and personal care products in the environment" No. 791, Washington, D.C., 206-228.
- Drewes, J. E. & Summers, R. S. (2002). Removal of NOM during bank filtration: Current knowledge and research needs. In: C. Ray, Melin, G. and Linsky, R. (eds.), Riverbank filtration: Improving source water quality. Kluwer Academic Publishers, Dordrecht, The Netherlands. 303-310.
- Drewes, J. E., Barrett, M., Appleyard, S., Chilton, J. & Fastner, J. (in press). Chemicals: Health Relevance, Transport and Attenuation. In: WHO Ground Water Monograph. World Health Organization (WHO), Geneva.
- Drewes, J. E. (2004). Fate and transport of organic constituents during ground water recharge using water of impaired quality. Risk Assessment of Waste Water Re-use on Groundwater Quality. J. Steenvoorden and T. Endreny (eds.). Wastewater Re-use and Groundwater Quality. International Association of Hydrological Sciences (IAHS) Publ. 285. 85-91. Oxfordshire, UK.
- Drewes, J. E. (2005). Wastewater Reclamation and Reuse Research. J.H. Lehr (ed) The Encyclopedia of Water. Wiley Water.
- Drewes, J. E., Gower, A., Mitchell, R. & Zabel, T. (2007). Chemicals: Health Relevance, Transport and Attenuation. In: WHO Surface Water Monograph. World Health Organization (WHO), Geneva.
- Xu, P., Drewes, J. E., Oedekoven, M., Bellona, C., Amy, G. (2007). Rejection of non-ionic organic micropollutants by nanofiltration membranes: Effect of membrane fouling. AWWA Best Membrane Papers Book. Kerry Howe (ed.). American Water Works Association (AWWA), Denver, Colorado.
- Drewes, J.E. (2007). Removal of Pharmaceutical Residues during Wastewater Treatment. Eds. M. Petrovic and D. Barcelo. Analysis, Fate and Removal of Pharmaceuticals in the Water Cycle. Vol. 50. Wilson & Wilson's. Elsevier, Amsterdam. 427-447.
- Ray, C., Grischek, T., Hubbs, S., Drewes, J.E., Haas, D. and Darnault, C. (2008). Riverbank Filtration for Drinking Water Supply. ASCE Riverbank Filtration. American Society of Civil Engineers. Riverbank Filtration Task Force. Wiley (in press).
- Drewes, J.E. and Khan, S. (in review). Water Reuse for Drinking Water Augmentation. J. Edzwald (ed.) Water Quality and Treatment, 6<sup>th</sup> Edition. American Water Works Association. Denver, Colorado.